SOFTWARE REVIEW

DXplain. Laboratory of Computer Science, Massachusetts General Hospital/Harvard Medical School. dxplain@mgh.harvard.edu. Demonstration program and licensing information available at http://www.lcs.mgh.harvard.edu/dxplain.htm.

For more than forty years, researchers have been working to develop methods that capture the reasoning used by physicians to arrive at diagnoses [1]. The goal is to combine the knowledge of disease characteristics with an expert system of rules or relationships to achieve this end. The knowledgebase of disease characteristics is incomplete; we do not know all of the factors associated with every disease. The relationship between a particular sign or symptom and a specific disease is one of probability not certainty—not everyone with chest pain is having a heart attack. Further, patients usually present with multiple problems, some more clinically significant than others. The clinician's initial task is to identify those problems and generate a list of hypotheses called the differential diagnosis. Some physicians do this better than others, and physicians' expertise varies across domains. Expert neurologists, for example, might not be very good at diagnosing endocrine disorders. Limitations in understanding how experts think limit the ability to model accurately and program the expert reasoning process.

After much effort and limited success, so-called ''expert systems'' have come to be referred to as diagnostic assist, or diagnostic support, programs instead, acknowledging somewhat less ambitious goals. They are not oracles that produce ''the answer,'' but assistants to the diagnostic process. These programs contribute what computers do well—they store and retrieve vast amounts of information and perform fast and accurate calculations (neither of which humans do well). People, on the other hand, are better at evaluating and synthesizing information in context, making judgments, and applying common sense. In this paradigm, the computer program and the expert collaborate to produce a better result. As one physician has put it, ''using these systems won't make a bad doctor a good doctor, but might make a good doctor a better doctor.''

Developed by Barnett and colleagues at the Massachusetts General Hospital/Harvard Medical School Laboratory of Computer Science, DXplain is one such diagnostic decision-support system. Barnett et al. described DXplain in a 1987 article [2] as ''an evolving diagnostic decision-support system.'' DXplain can be licensed for educational use and is available on the Web. Its knowledgebase includes approximately 5,000 clinical manifestations associated with more than 2,000 diseases. Each disease description has at least ten current references. Thus, DXplain is also advertised as an electronic textbook and medical reference system.

DXplain presents dialog boxes with these three options: (1) differential diagnosis of a finding, (2) disease description, and (3) evidence for a diagnosis in context of a case presented for analysis. For example, if ''dyslipidemia'' is entered, it is not found in the vocabulary of the program. However, a dialog box helps users find ''hyperlipidemia'' as the most relevant term. When hyperlipidemia is entered as a finding, an extensive differential diagnosis of conditions associated with it is produced. If hyperlipidemia is entered as a disease, a more limited list of the several types of hyperlipoproteinemia is generated. Disease descriptions are organized according to the following topics: definition, other names, etiology, associated terms and conditions, symptoms, physical findings, laboratory findings, diagnostically helpful information, course, pathology, and references. Finally, if users enter key findings typical of familial hypercholesterolemia (e.g., young patient with increased cholesterol and recent myocardial infarction), the system lists that diagnosis and other common diseases. It also lists some inappropriate diagnoses such as multiple myeloma, as well as rare diseases that might cause the current ensemble of findings. As analysis proceeds, more information can be entered by users, or the system will seek additional findings through dialog boxes requiring ''Yes,'' ''No,'' or ''Unknown'' responses. This process is continued through as many iterations as users choose. Contradictory or mutually exclusive findings are recognized as such and not allowed. When enough information has been provided to the system to exceed its diagnostic threshold, it lists the probable diagnosis as ''++,'' indicating there is sufficient information to strongly support this diagnosis.

Results of a few real and contrived cases show the program can be quite adept. For example, it recognizes the association of rheumatoid arthritis and pneumoconiosis as Caplan's Syndrome and provides suitable references through seamless access to PubMed (really slick when everything works just right!). Another diagnostic assist program allows rheumatoid arthritis and pulmonary silicosis to coincide but not as a single entity, and yet another program does not even recognize the association. In another example, DXplain recognizes symptoms of hypocalcemia but does not recognize the cause as blood transfusion leading to citrate toxicity. Further, it does not generate other associations of massive transfusion, such as coagulopathy. This only shows that it easy to identify syndromes, or collections

of findings, not recognized by DXplain. It is well known that multiple diseases interact in ways that are impossible to model. This missing information in DXplain illustrates the exceptional breadth and depth of knowledge upon which experts can draw. DXplain has an extensive repertoire of diagnoses, but it is not encyclopedic. It would be interesting to know the underlying algorithms used to generate and rank diagnostic hypotheses, but to the best of the reviewers' knowledge the rules for manipulating the database are not published.

The interface is simple and for the most part intuitive. Occasionally, it requires a mouse click on the relevant menu box when a simple ''Enter'' may be easier, as when terminating the input list. Ease of use is not all it could be. Entering data can be tedious, and the enormous vocabulary of users must be translated into terms recognized by the system. Thus, ''thyroid acropachy'' is not recognized by DXplain (although it is present in another diagnostic assist system), and ''pretibial myxedema'' is not recognized and must be entered as ''tibial skin dimpling.'' Synonym identification is usually helpful, although the system by no means includes all terms in medical jargon. For example, it takes considerable effort to get from ''hydrophobia'' to ''drooling'' as the closest matching term and from there to rabies as one of its several causes. The system times out after short intervals, resulting in the loss of all input, and then requires reentry of username, password, and demographic information. It is possible to save a single case but not multiple cases. Occasionally, the system abruptly and unexpectedly logs off. These problems are minor and do not significantly alter the utility of the program.

London has discussed DXplain's use by medical students, particularly as a tool for problem-based learning (PBL) and clinical rotations [3]. Students and residents preparing for clinicopathologic conferences (CPCs) or other diagnostic exercises may be interested in DXplain or a similar program. Over the years, Texas Tech University and Texas A&M University have used the Iliad and QMR diagnostic assist programs in informatics elective courses to illustrate the concepts of defining a disease database and modeling the diagnostic process [4, 5]. Students are quick to realize that these systems force them to use more specific terms. Usually, it is the first time students have seen this kind of program, and it is an opportunity to discuss the complexity of the diagnostic task, user-interface issues, and specialized diagnostic systems, such as electrocardiogram interpretation programs, already in clinical use. Today's students are sure to see variations of diagnostic assist software during their careers. Early exposure, in a learning environment where it is natural to critique content and features, may make them more savvy users of programs designed to assist them.

In summary, DXplain is one of only a few mature and powerful diagnostic assist systems that encompass a large spectrum of medical problems. It is easy enough to use for a quick answer and yet powerful enough to complement the skills of an expert. It can be a useful tool in educating students about the diagnostic process. DXplain represents the state of the art in its class and is worthy of wider use and continued development.

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References

1. MILLER RA. Medical diagnostic decision support systems—past, present, and future: a threaded bibliography and brief commentary. JAMIA 1994 Mar–Apr;1(2):8–27.
2. BARNETT GO, CIMINO JJ, HUPP JA, HOFFER EP. DXplain: an evolving diagnostic decision-support system. JAMA 1987 Jul 3;258(1):67–74.
3. LONDON S. DXplain: a Web-based diagnostic decision support system for medical students. Med Ref Serv Q 1998 Summer;17(2):17–28.
4. BARTOLD SP, HANNIGAN GG. Diagnostic computing: an elective for fourth-year medical students. Medinfo 1995;(8 pt. 2):1165.
5. HANNIGAN GG, BARTOLD SP, BROWNE BA, FULTON S, HENRY BJ, MALCOM P, MATTHEWS TK, MCCULLOUGH EH, MOSHINSKIE JF, TONN-BESSENT J. Computers and medical information: an elective for fourth-year medical students. Med Ref Serv Q 1996 Winter; 15(4):81–8.